Sedimentary facies of the Byakubi-E tephra bed (Byk-E) just below the Matuyama-Brunhes Polarity Chronozone boundary in Boso Peninsula, central Japan

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The Byakubi-E tephra bed (Byk-E) is a white pumiceous fine ash deposit with 1.0-7.0 cm thick, and is sandwiched between dark gray sandy silt layers in the middle part of the Kokumoto Formation (Kazusa Group).
The Byk-E is located at approximately 0.8 m below the Matuyama-Brunhes Chronozone boundary (MBB) in the Chiba composite section (along the Yoro, Yanagawa and Kokusabata rivers) in central part of the Boso Peninsula (Suganuma et al., 2015; Kazaoka et al., 2015). The middle part of the Kokumoto Formation across MBB is extremely well exposed in the Chiba composite section, and this section is a candidate of Global Boundary Stratotype Section and Point (GSSP) for the Lower-Middle Pleistocene boundary (Head et al., 2008; Head and Gibbard, 2015). The base of the Byk-E would serve as an appropriate level for of the L-M Pleistocene GSSP, because that is a clear lithofacies boundary just blow the MBB (Kazaoka et al., 2015).
It has been revealed that a distribution of the Byk-E in the Boso Peninsula (Kazaoka et al., 2015) and its source volcano (Takeshita et al., 2015), however, there is no detailed report on the sedimentary facies of this tephra bed. Therefore, we carried out a detailed observation of the sedimentary facies of the Byk-E in four outcrops (Yoro and Yanagawa rivers, Mt. Daifuku, and Tateyama). As a result of the observation, following three points were found in neither outcrop. 1) There is not a clear lamina in the Byk-E. 2) Mud clasts are not observed in the Byk-E. 3) The base of the Byk-E doesn’t cut trace fossils in the underlying layer. Additionally, in the three outcrops except the Yoro River section, the thin layer consisting of fine volcanic ashes is found in a basement of the Byk-E. These results clearly show that the Byk-E is a primary fall-deposits, and conformably overlies the underlying silty layers.

Keywords: Byk-E, Lower-Middle Pleistocene boundary, GSSP, Sedimentary facies, Chiba composite section

Zircon LA-ICP-MS U-Pb dating on some Quaternary tephras in Boso Peninsula

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Zircon U-Pb dating using LA-ICP-MS was applied to some Quaternary tephras in Boso Peninsula, central Japan. Accurate age determination of these tephras is of critical importance because they are relevant to a candidate site for the Global Boundary Stratotype Section and Point of the early-middle Pleistocene boundary. Recently, a precise zircon SHRIMP U-Pb age of 0.773 ±0.007 Ma from a tephra just below the Matuyama-Brunhes (MB) boundary was reported (Suganuma et al., 2015). Here, we show other precise zircon LA-ICP-MS U-Pb ages from the Ks11 and Ch2 tephras above the MB boundary. The Ks11 tephra yielded a weighted mean age of 0.52 ±0.04 Ma and the Ch2 tephra yielded a weighted mean age of 0.61 ±0.02 Ma, both of which are in agreement with the stratigraphy. The good agreement between zircon U-Pb ages and the stratigraphy validates the reliability of the established stratigraphy and our dating approach. These U-Pb ages should help to further establish Japanese and worldwide Pleistocene chronostratigraphy.

Keywords: U-Pb dating, zircon, tephra, Matuyama-Brunhes boundary

Orbital and suborbital scale paleoceanographic features for marine isotope stage 19 from the Chiba section well correlated with those from Osaka Bay and North Atlantic

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Chemical and magnetic data of a 54-m long core drilled near the Chiba section, Tabuchi provide excellent proxies of sea-level variations. The Ca/Ti ratio, magnetic susceptibility, ARM, and ARM/magnetic susceptibility values measured every 1 cm interval show variations well correlated with those from the oxygen isotope data from planktonic foraminifera fossils. The existence of such correlations reflects combined effects of changes in biogenic calcium carbonate production, accumulation rate (a.r.) and grain size of clastics due to sea-level variations. The Ca/Ti curve, a best sea-level proxy, shows precession-related signals correlated with highstands 19.3 and 19.1, and lowstand 19.2. The orbitally tuned Ca/Ti curve represents a number of centennial scale features well correlated with those of sea-level proxies from Osaka Bay and North Atlantic. In consideration of a.r. variability, the age model for the Chiba section was refined with more control points between the orbital scale control points, adjusting to the astronomical time scale for the Osaka Bay core that has a uniform a.r. In the early MIS 19, the highest sea-level peak is preceded by a sea-level fall event, as in Osaka Bay. After MIS 19.2, there are many millennial scale fluctuation features, most of which are observed in the records from Osaka Bay and North Atlantic (IODP site U1313). These features are possibly global, and some of them are affected by eustatic sea-level changes. The MBB is dated at 777 ka in Osaka Bay, and 778 ka in the Chiba section and the North Atlantic.

Keywords: Chiba section, Matuyama-Brunhes boundary, Osaka Bay, North Atlantic, sea-level variation

Planktonic foraminiferal biostratigraphy and paleoceanographic reconstruction of the Pleistocene Kokumoto Formation, Kazusa Group in the Boso Peninsula, Japan

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The Plio-Plestocene Kazusa Group is widely distributed in the Boso Peninsula. The Matuyama-Brunhes reverse boundary (MBB) has been recognized in the Kokumoto Formation of the upper part of the Kazusa Group. To reconstruct a detailed paleoceanographic record of environmental change across the early-middle Pleistocene boundary, we carried out a faunal analysis of planktonic foraminifera from a sediment core (TB2) obtained from the Kokumoto Formation at Tabuchi, Ichihara City, Chiba Prefecture, central Honshu, Japan. We also reexamined a planktonic foraminiferal biostratigraphy extending from the Kokumoto Formation to the lower Kakinokidai Formation along the Yoro River section, in order to identify important planktonic foraminifera biohorizons.
The 54-m core mainly consists of massive siltstone with a key tuff bed (Byakubi-E) and covers marine oxygen isotope stages (MIS) 20.2 to 19.2 with a high sedimentation rate of 1–2 m/ka. Total 41 species belonging to 15 genera of planktonic foraminifera were detected from 59 samples of the TB2 core. We reconstructed sea surface temperature and salinity based on the planktonic foraminiferal assemblages by using the Modern Analog Technique and the Transfer Function method. The results clearly demonstrates the migration process of the Kuroshio front from stages 20 to 19. The biostratigraphic result of the Yoro River section indicates that the top occurrence datum of *Neogloboquadrina inglei* Kucera and Kennett is placed near the boundary between Kokumoto and Kakinokidai formations. This biohorizon has been dated as 0.73 +/- 0.05 Ma at Ocean Drilling Program Site 1150 off the Sanriku region, Northwest Pacific (Domitsu and Oda, 2008, The Open Paleontology Journal, 1, 1–6). Combining with previous studies, we refined the planktonic foraminiferal biostratigraphy of the Kazusa Group.

Keywords: Kokumoto Formation, planktonic foraminifera, biostratigraphy, paleoceanography

Detailed variations in diatom assemblages across the Matuyama-Brunhes magnetic polarity boundary from a core collected adjacent to the Chiba section, central Japan

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We conducted diatom analysis of a core named TB2 of the Kokumoto Formation of the Kazusa Group drilled near the Chiba section, a candidate for the Early to Middle Pleistocene boundary. 71 taxa of diatoms were identified. The number of total valves is controlled by coastal species such as *Paralia sulcata*, *Cyclotella striata* + *C. stylorum*, and *Actinoptychus senarius*. The coastal species show variations well correlated with the ratio of Ca/Ti, a biological production proxy, and planktonic $\delta^{18}O$, representing the highest peak at 44.5-33.9m and the second one at 19.9-14.8m. The former is correlated with highstand MIS 19.3 and the latter with highstand MIS 19.1. This result suggests not only the biogenic production rate but the production of coastal diatom species increases as the sea-level rise. Cold diatom species of the Oyashio Current are dominant below a depth of 25 m, and warm species of the Kuroshio Current become dominant above it. This suggests occurrence of a large current system change during MIS 19.

Keywords: Paralia sulcata, MIS 19, Kokumoto Formation, Matuyama-Brunhes magnetic polarity boundary

High resolution magnetostratigraphy of the Matuyama-Brunhes transition from oriented samples from the Chiba Section, central Japan

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Pleistocene sediments of the Kokumoto Formation in the upper part of the Kazusa Group, central Japan have been studied by many research groups. However, very few studies have focused on the marine isotope stage 19 interglacial including the Matuyama-Brunhes magnetic polarity boundary (MBB). In order to establish detailed magnetostratigraphy across the MBB, we collected oriented samples for magnetic analyses by drilling from 140 horizons of the Chiba Section, a candidate for the Global Boundary Stratotype Section and Point (GSSP) of the Early to Middle Pleistocene Boundary. We also collected block samples to pick up foraminifera fossils from 35 horizons for construction of oxygen isotope stratigraphy. Here, we first report preliminary results of paleomagnetic analyses. Progressive thermal demagnetizations reveal natural remanent magnetizations (NRMs) consist of two components demagnetized at or below 350 degrees Celsius and between 500 degrees Celsius and 680 degrees Celsius. The values of magnetic susceptibility measured at each step of thermal demagnetizations begin to increase from 400 degrees Celsius and decrease above 500 degrees Celsius. These results indicate that the samples include a ferromagnetic iron sulfide mineral such as greigite, which is decomposed below about 350 degrees Celsius, followed by oxidation to form magnetite and further to hematite, causing an increase and a decrease of magnetic susceptibility, respectively. Characteristic remanent magnetizations isolated above 350 degrees Celsius show that reverse and normal polarity continue from 1440 cm below to 60 cm above and from 290 cm to 430 cm above the Byakubi tephra (Byk-E), respectively. Therefore, the Matuyama-Brunhes transition would lie between 60 cm and 290 cm above the Byk-E, which would require reviewing the previous MBB position in detail. The result of oxygen isotope analysis using fossils of *Bolivinita quadrilatera* will also be reported.

Keywords: Early to Middle Pleistocene GSSP, Chiba Section, Matuyama-Brunhes boundary, Bolivinita quadrilatera, MIS19, Byakubi-E

The Tokyo Bay Unconformity and the Mandano Ice- Age

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The Kanto fore-arc basin in the Kato plain is an extremely deep submarine basin that was formed during the early Pleistocene. The sediments in the basin change from deep-sea sediments to lacustrine-alluvial sediments, the Mandano formation which is up to 95 m in thickness and overlays the Tokyo Bay unconformity that is widely distributed under Tokyo bay area. The formation consists of three parts. The lithofacies in the lower part on the unconformity gradually change, with decreasing depth, from sand to gravel. The lithofacies of the middle part are muddy. The upper part changes with increasing depth from gravel to sandy shilt by transgression. The lower part and lower half of the middle part comprise sediments characteristic of a topset fan delta (Nirei H., 1997) in the regression stage. The upper half of the middle part and upper parts are composed of transgression sediments. The lower half of the middle part contains sediments from the ice age regression stage, evidence of which is provided by the cold-index plant remains,Picea maximowiczii, Tsuga diversifolia,Fagus crenata, Cryptomeria japonica, etc., present in the uppermost part of the lower half. Geological analysis reveals the Kanto continental shelf to extend widely under the Kanto Plain; it is also underlaid by a range of bottom set sediments in distinct formations and forest sediments, also in distinct formations, in ascending order under the conformity.

Keywords: Tokyo bay unconformity, Mandano ice-age

Revised Matuyama-Brunhes polarity transition record from a marine succession at the Chiba section, a Lower-Middle Pleistocene GSSP candidate

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We report revised paleomagnetic records of the Matuyama-Brunhes boundary (MBB) from a continuous marine succession at the Chiba section of the Kokumoto Formation, Kazusa Group. The Chiba section is the one of the candidate sites for the Lower-Middle Pleistocene Boundary GSSP. In the section, a wide spread tephra bed named as Byk-E is intercalated just 80 cm below the MBB. In order to provide globally comparable VGP (virtual geomagnetic pole) and paleointensity (past geomagnetic field intensities) records from the Chiba section, we have taken oriented mini-cores from a 13 meters succession with 10-cm intervals across the Byk-E tephra bed. Thermal magnetic experiments suggest that the samples include iron sulfides, magnetites but no hematite. Measurements of magnetic hysteresis indicate that the magnetic domain state is PSD. Progressive alternating field demagnetization (AFD) indicate a reversed to normal polarity transition boundary is at around 1.5 meter below the Byk-E bed as well as previous studies, however the transition boundary is observed at around 0.8 meter above the Byk-E bed in thermal demagnetization (ThD) results. Therefore, the reversed to normal polarity transition boundary seen below the Byk-E bed is thought to be overprint. This overprint, which might be carried by iron sulfide, is particularly observed in a transitional interval. Since iron sulfides generally decompose and oxidized into magnetites due to heating during ThD, the yielded magnetites have no magnetic signal but provide an over estimate of magnetic grain amount which prevents to estimate paleointensities. To provide a reliable paleointensity record, we applied to use a composite demagnetization technique consisting of a 300° C ThD and a regular progressive AFD sequence. After the 300°C ThD, most of the overprint has been removed but the magnetic susceptibility has not changed even in the air condition, indicating that iron sulfides just lose magnetic signals due to the ThD but not to change the amount of magnetic grains. The VGP latitudes and preliminary derived paleointensities using the composite demagnetization technique from the Chiba section quite match well with the U1308 records. To use the both independent techniques of oxygen isotope and paleointensity will provide a further reliable stratigraphic correlation across the Lower-Middle Pleistocene Boundary.

Keywords: Paleomagnetism, Paleointensity, GSSP

A preliminary report for high-resolution foraminiferal oxygen and carbon stable isotope records in MIS 19 from an on land core drilled at the Choshi city, central Japan.

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The Plio-Pleistocene Inubo Group, distributed in the Choshi city, Chiba prefecture, central Japan, is though to be a suitable marine succession to investigate paleoceanographic and paleoclimatic changes around the northwestern Pacific Ocean, because a lot of wide spread key tephra beds are intercalated, and microfosills and pollens are abundant. In 1998, a continuous, well recovered on land core drilled through the Obama, Yokone, Kurahashi and Toyosato Formations in the Inubo Group was obtained (after Choshi core). Kameo et al. (2006) studied calcareous nannofosill, paleomagnetic and planktonic foraminiferal oxygen isotope stratigraphies of the Choshi core, and reported that the core corresponded to a period between MIS 11 and 24 base on a correlation with the LR04 stack curve (Lisiecki and Raymo, 2005). In this study, we show a new high-resolution stable isotope record using benthic foraminifers from a section across the Lower-Middle Pleistocene boundary of the Choshi core. This record corresponds to MIS 18-20 with a time resolution of ca. 500 years. The average oxygen isotopic value of the Choshi core is about 0.5 ‰lighter than that of LR04 during the period of MIS 19, and the difference becomes larger as the age becomes younger, indicating that the accumulation depth of the Coshi core was getting shallower due to uplifting and/or burring up the basin. Further analysis on the core will show some paleoceanographic findings at around the north western Pacific margin during the MIS 19 period.

Keywords: MIS 19, Foraminiferal stable isotope record, Choshi core

Calcareous nannofossil biostratigraphy of the Lower-Middle Pleistocene in the Kazusa Group, central part of the Boso Peninsula, and estimated sea surface environments

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Quaternary marine sediments, called the Kazusa Group, distribute in the Boso Peninsula situated in the middle part of the Pacific side of Japan. Lithostratigraphic and chronostratigraphic investigations have been done (Niitsuma, 1976; Sato et al., 1988; Igarashi, 1994) because the formations in this Group are well exposed and contain well-preserved fossils. The Matuyama/Brunhes boundary (MBB) is situated in the Kokumoto Formation, the upper part of the formations in the Kazusa Group, and this formation is one of three candidates for the GSSP (Global Boundary Stratotype Section and Point) of the Lower-Middle Pleistocene Boundary (Kazaoka et al., 2015). Thus, in order to determine a precise age of the Lower-Middle Pleistocene Boundary in this formation, detailed chronostratigraphic and chronometric studies are needed. In this study, we investigate calcareous nannofossil assemblages in the Kokumoto Formation in order to clarify nannofossil biohorizons and to estimate sea surface environment around the MBB in the northwestern Pacific region during the early to middle Pleistocene. Ten genera and 19 species of calcareous nannofossils were found in 66 samples from the Kokumoto Formation. Floral compositions are almost same throughout the examined interval. Abundant occurrences of small *Gephyrocapsa* were markedly found just above the MBB in the Kokumoto Formation. This event was also recognized in the Montalbano Jonico and Valle di Manche, the southern part of Italy (Girone et al., 2013) and it can be globally traceable event. Furthermore, an inverse relationship of occurrences between a cool water taxa, *Coccolithus pelagicus*, and a warm water taxa, *Umbilicosphaera sibogae*, is found. It indicates that the Kuroshio front, which corresponds with the boundary between the Kuroshio and the mixed waters, has moved northward and southward repeatedly during the early to middle Pleistocene.

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Detailed litho-stratigraphy and sedimentary environment of upper part of Kokumoto Formation with the L-M Pleistocene boundary: the Chiba section, Central Japan

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The Lower –Middle Pleistocene Kazusa Group, deposited on mainly bathyal –shelf in the Pacific Ocean with many kind of fossils, distributes widely in Boso peninsula. The Kazusa Group exposes continuously along Yoro river, Chiba section, type section of the group. The Kazusa Group consists of Kurotaki Formation (mainly tuffaceous gravelly sandstone), Katsuura F. (mainly alternation of sandstone with slump bed), Namihana F. (mainly siltstone with slump bed), Ohara F. (muddy alternation of sandstone and siltstone), Kiwada F. (muddy alternation of sandstone and siltstone with slump bed), Otadai F. (alternation of sandy alternation and muddy alternation of sandstone and siltstone), Umegase F. (mainly sandy alternation of sandstone and siltstone), Kokumoto F. (alternation of thick siltstone and sandy alternation of sandstone and siltstone), Kakinokidai F. (sandysiltstone with sandstone) and Chonan F. (alternation of thin sandstone and thin siltstone) in ascending order (Mitsunashi et al., 1959). Total thickness of the Kazusa Group is over 2,000 meters with over 50 marker tephra beds. Trapid depositional rates of 2.0-2.5 m/ky are obtained for the Kazusa Group. Therefore the Chiba section have high potential for international stratotype section (Kazaoka et al., 2015).
Kokumoto Formation, about 350 meter thick, is composed of the lowermost part, the lower part, the upper part and the uppermost part in ascending order. The lowermost part, about 60 meter thick, consists of thick siltstone with thin sandstone bed and marker tephra, Ku6 and ku5. The lower part, about 120 meter thick, consists of sandy alternation of sandstone and siltstone with Ku3 tephra. The upper part, about 80 meter thick, consists of thick siltstone with thin sandstone and marker tephra (Byakubi zone (Byk-G, Byk-F, Byk-E, Byk-D, Byk-C, Byk-B and Byk-A), Koss2, Koss1-B, Koss1-A, Kosp-C, Kosp-B, Kosp-A, Tap-B, Tap-A, Tas-C, Tas-B, Tas-A, Ku2 and Ku1). Especially maker tephra are interbeded every 0.1-7.0 ky in the thick siltstone from Byk-E to Ku2 horizon. The Matuyama-Brunhes boundary is between Byk-C and Byk-B. Uppermost part, about 90 meter thick, consists of sandy alternation of sandstone and siltstone with Ku0.1 tephra.
The upper part, thick siltstone, is interbedded with thin, 1-3cm thick, sandstone every 0.3-3 m thick and thin, 1-5 cm thick, sandysiltstone every 0.1-0.25 m thick without slump bed and thick mudflow bed. The siltstone have bathyal and sublittoral benthic foraminifera and many trace fossils. Grain size distribution in the siltstone have bimodal grain group (Nishida et al., 2015). Main grain group is composed of fine silt and sub group consists of very fine sand. These characteristics show hemipelagic sedimentary environment in deep sea and very fine sand flow often into, namely deep sea slope. The thickness from Byk-G to Byk-A change little laterally in the central part of Boso Peninsula. This show that the fracks deposited approximately uniformly. It is presumed that clastic sediments were supplied little around here from source mountain area, because this horizon is warm stage, MIS 19.

Keywords: L-M Pleistocene boundary, Kokumoto Formation, Kazusa Group, Maker Tephra, Byk-E, MIS 19

